SOCIAL PREFERENCES IN A COMMON-POOL RESOURCE DILEMMA

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Abstract

The simplifying assumption of rational self-interest is a common one in the social sciences, however it may not always be entirely realistic. People can also adopt a variety of alternative social preferences that place weight on both private and group outcomes. Using experimental methods from economics and psychology, this paper empirically estimates these different "social value orientations" (SVOs), ranging continuously from relatively proself social preferences (competition and individualism) to relatively prosocial (altruism and cooperation). This measure is then applied to a common-pool resource (CPR) experiment to test if social preferences can be used to predict strategic harvesting decisions or participation in a peer-enforced regulatory institution. I find that perfect self-interest is one of many consistent forms of social preference, and that prosocial (proself) preferences successfully predict lower (higher) rates of resource extraction. Social preferences can also be used to predict regulatory participation, but the long-run relationship is less clear.

Table of Contents

Page

Signature Page....................i

Title Page....................iii

Abstract....................v

Table of Contents....................vii

List Of Figures....................ix

List of Tables....................xi

List of Supplemental Files....................xiii

Acknowledgments....................xv

Introduction....................1

Background....................5

Common-Pool Resource Dilemmas:....................5

Social Value Orientations:....................9

Design....................19

The SVO Slider Method:....................19

Common-Pool Resource Game:....................24

Experiment....................31

Procedure:....................31

Hypotheses:....................35

Results....................39

Page

Social Value Orientation Experiment:..39

Common-Pool Resource Experiment:..46

Conclusion..57

References..61

List Of Figures

Page

Figure 1: The SVO Ring....11

Figure 2: Primary & Secondary SVO Slider Items....21

Figure 3: SVO Distribution....40

Figure 4: Inequality Aversion Index....43

Figure 5: Average Group Extraction....47

Figure 6: Average Unregulated Extraction....48

Figure 7: Average Sanction Usage....50

Figure 8: Sanctions Received....53

List Of Tables

Page

Table 1: Decomposed Game Example..15

Table 2: Experiment Parameters...28

Table 3: Sample Statistics...32

List of Supplemental Files

File 1: Treatment Code

File 2: Informed Consent Form

File 3: Experiment Instructions

File 4: Earnings Table & Record

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Introduction

Common-pool resource (CPR) theory provides us with valuable insight into some of the world's most complex and pressing environmental problems. To make sense out of why endangered species are hunted to extinction, tropical rainforests become clear-cut, or oceans are drained of fish, one needs to understand not just the man-made rules that govern our shared natural resources, but also the unique incentives and social preferences of people in the global commons. Great strides have been made in deconstructing the determinants of group cooperation in CPR dilemmas over the last twenty years. Many of these developments have focused on various institutional factors that promote the efficient and sustainable harvest of common pool goods. More recently, there has been a great deal of interest in how individual-level behavioral differences also factor into resource allocation decisions (Stoop et al., 2013; Van Soest & Vyrastekova, 2006). There has also been a related interest in whether these behavioral heterogeneities can result in non-uniform responses to institutional treatments (Moeltner et al., 2013).

While no doubt a useful starting point for modeling behavior, the common simplifying assumption of perfectly rational resource users, interested solely in the maximization of their private rents, has been criticized as unrealistic and not universally applicable to all economic decision makers (Levitt & List, 2008). Differences in "social value orientations" (SVOs), which describe the weighting people place on their own material outcomes relative to the outcomes of others, have been proposed as one way of extending the traditional behavioral framework of rational choice theory to incorporate important “other-regarding” preferences (Kopelman et al., 2002). The extent to which the perceived welfare of others influences behavior in a CPR dilemma may potentially be just as important for understanding decision making as the institutional regime under which choices are made.

Using experimental methods from economics and psychology, this paper attempts to answer three main questions regarding the intersection of these preferences and the social dilemmas related to CPRs. Firstly, how well does the theoretical ideal of rational self-interest actually describe the social preferences people possess? Many resource users no doubt adopt a so-called “individualistic” orientation and only consider their private benefits as standard rational choice theory predicts. However this is just one of many possibilities from a wide range of potential SVOs. It may be more reasonable to assume a heterogeneous mixture of both individualistic preferences and other-regarding preferences such as altruism, joint-maximization or competition.

Secondly, if differences in social preferences can be distinguished, can they also be used to predict extraction behavior under the normal strategic conditions of a CPR dilemma? Information on an individual's professed social values are of little use to economists or environmental policy makers unless those values can also be used to predict systematic disparities in the harvest strategies of users with different preferences. Having a way to measure group composition in terms of SVO, along with any associated variations in expected extraction rates could be a valuable information input.

Lastly, if SVO can be used as an *a priori* predictor of extraction behavior, can it also be used to predict differing responses to institutional treatments? Group-enforced regulations in the form of monetary sanctions are a standard tool to increase gross efficiency in CPR experiments (Ostrom et al. 1992). If SVOs can be used to predict participation in peer-sanctioning activities, then information on this institutional heterogeneity could also be of great use when designing experimental treatments, or even real-world instruments aimed at discouraging resource exploitation.

In order to answer these questions, a series of economic experiments were conducted to empirically estimate differences in social preferences, and test whether these qualities are a valid predictor of certain behaviors in CPR dilemmas. While this is far from the first attempt in the literature, this paper makes a few modest contributions to the existing body of experimental research. First, compared to other social traps modeled using public goods games or one-shot prisoner's dilemmas, the influence of SVO on repeated, *n*-person CPR games has received comparatively little attention (Balliet et al., 2009). This is unfortunate given that many natural resources have common-pool properties, and ensuring the sustainable use of these goods is key to many relevant environmental problems.

Second, many prior attempts to link SVO and social dilemma behavior have employed relatively basic categorical measurement methods (Brosig, 2002; Van Soest & Vyrastekova, 2006). I adopt a more modern and sophisticated estimation technique recently developed by Murphy et al. (2011) known as the "SVO Slider Method". This method produces a ranked and transitive measure of SVO over a continuous spectrum ranging from relatively proself social preferences (competition and individualism) to relatively prosocial (cooperation and altruism). Treatment of SVO as a continuum is more consistent with the concept's theoretical origins, allows for more accurate descriptions of social preferences, and provides an efficient econometric tool for determining any effect on strategic behaviors.

The remainder of this study is organized as follows: first I begin with some of the obligatory background information on the nature of CPR dilemmas, as well as a review of the theoretical framework for social preferences. This is followed by an explanation of how preferences are estimated using the SVO Slider Method, as well as the model used to simulate the CPR dilemma experimentally. After a description of the experimental protocol, I outline some testable hypotheses. Finally I discuss the results of the experiment. I conclude with a review of my findings, and ideas for further research avenues.

Background

Common-Pool Resource Dilemmas:

The efficient long-run use of shared natural resources is frequently undermined by the “subtractable” (rivalrous) and “non-excludable” nature of common-pool goods (Ostrom et al., 1994, p. 7). When the costs associated with regulating access to a resource stock are prohibitively high, it is considered functionally “non-excludable”. Given that barriers to entry and exit are trivial or non-existent, anyone is free to enter the commons, extract the shared resource, and exit once the stock's profitability has been depleted. This is often the case with natural resources that are diffuse, and flow between man-made borders (fresh water sources, migratory animals, etc.), or are contained within large areas that make traditional monitoring and regulation impractical (fisheries, timber lands, etc.). When these resources are also “subtractable” (rivalrous), each unit consumed tends to reduce the aggregate level of the resource stock by a proportional amount. Any goods extracted by one user are thus unavailable to be consumed by another user, or to be consumed at some later date.

Since the easiest way to extend property rights over common pool goods is through the destructive process of extraction and consumption, the predicted strategy for a rational, perfectly self-interested resource user is to extract as fast as possible before any rivals have a chance to do the same. This results in a social dilemma where no individual resource user has an incentive to moderate their consumption of the good while the consumption strategies of other users remains unchanged. Marginal benefits accrue directly to the individual, while marginal costs are largely externalized amongst the group. Barring some form of external or internal regulatory institution, CPRs tend to be over-exploited, and in extreme cases exhausted entirely. This “rent dissipation”, ultimately results in net deadweight loss to society (Walker et al., 1990).

Economic descriptions of CPR dilemmas date at least as far back as the early 19th century when British political economist William F. Lloyd first documented the overgrazing that plagued much of Europe’s communally held pastoral lands (1833). In the 1950s the general problem was formalized mathematically in the pioneering fisheries models of Gordon (1954) and Scott (1955). However, it was not until 1968, and the publication of ecologist Garret Hardin's seminal essay on “The Tragedy of the Commons”, that the problem was truly popularized, and began receiving broader attention from social scientists.

Hardin’s influential analysis left little room for optimism. Drawing on Lloyd’s earlier study of herdsman behavior, Hardin argued that the “rational” CPR user, concerned only with their own myopic gain, would invariably over-exploit and destroy shared natural resource stocks. “Ruin”, he declared, “is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons” (p. 1244).

It was assumed that unless people were bound by social arrangements of "mutual coercion, mutually agreed upon by the majority of the people affected", over-exploitation of the commons was all but inevitable (p. 1247). Hardin conceded that well-defined property rights, whether held by the state in a socialist system or by private parties in market economies, could potentially prevent resource degradation. However he also professed skepticism that formal property rights would be feasible in many instances. He ultimately believed that in most instances the Tragedy of the Commons was simply beyond "technical solution", and instead required a more radical "fundamental extension in morality" in order to prevent ecological collapse (p. 1243).

This dismal narrative – in which uniformly rational and self-interested resource users find themselves in an inextricable social trap, that is doomed to end in tragedy – became conventional wisdom on the subject for many years (Feeney et al., 1996). However, beginning chiefly in the early 1990s, a large body of evidence has since developed in contrast to Hardin's mutually assured destruction (Ostrom et al., 1992; Ostrom et al., 1994; Ostrom & Walker, 1991). Studies based on both field evidence and experimental replication have found numerous instances where the Tragedy of the Commons fails to materialize under the conditions one would normally expect (Basurto & Ostrom, 2009). While CPR dilemmas frequently do end in tragedy, it is now widely acknowledged that this outcome need not be considered a foregone conclusion. Under proper conditions, individuals tend to develop formal and informal institutional arrangements to solve open-access problems and overcome social dilemmas (North, 1990). While formal property rights are costly to establish, informal institutions such as social pressure, or ostracism can also be an effective and complementary tool to induce group cooperation. Worst case scenarios like the Tragedy of the Commons are most likely to occur only when certain conditions are met with respect to the resource and its users; namely "when resource users are totally anonymous, do not have a foundation of trust and reciprocity, cannot communicate, and have no established rules" regarding extraction (Basurto & Ostrom, 2009, p. 255).

While the institutional dimensions of the CPR dilemma have received a great deal of attention already, recently more interest has been directed at how "asymmetries" in resource harvest can also be attributed to behavioral heterogeneities among users (Jacquet et al., 2013). While Hardin based his arguments on the expected behavior of perfectly rational and self-interested individuals, recent avenues of research have attempted to incorporate the possibility of other SVOs to see how preferences regarding trust, reciprocity, altruism, equity, cooperation or competition manifest in different extraction patterns between otherwise identical users (Ostrom, 1998; Stoop et al., 2013; Van Soest & Vyrastekova, 2006).

Social Value Orientations:

While the terminology adopted here has its roots in behavioral economics and psychology, the concept of social value orientations is one that is inter-disciplinary and should be familiar to most social scientists by one name or another. Generally speaking, an individual's SVO refers to the intrinsic social preferences that underlie their decision making under conditions of mutual interdependence. More specifically, these orientations describe the weighting individuals place on their own material outcomes relative to the outcomes of others. This postulates that an individual's utility can be a function not just of their own material payoffs, π_i , but also the payoffs of others, $\pi_{j \neq i}$. This gives decision makers a general utility function of the form, $U_i = f(\pi_i, \pi_{j \neq i})$. The precise functional form, as well as the sign and magnitude of each argument are what ultimately define a decision maker's SVO. This concept has also been referred to as “other-regarding preferences”, “welfare tradeoff ratios”, “collective interest”, “social utility”, or a plethora of other terms depending on the field of behavioral science being surveyed.

This wide variety of discipline-specific jargon for what is ultimately a singular concept speaks to the shared interest of economists, psychologists, political scientists, and other researchers in accounting for how individuals behave when their choices have material consequences on the welfare of others. Within economics specifically, the idea that subjective utility can be a function not just of an individual decision maker's outcome, but also the outcomes (or at least the perceived outcomes) of others, is not a new or particularly novel idea. The notion is at least as old as the field itself, with practitioners as far back as Adam Smith indirectly acknowledging the importance of SVOs. In *The Theory of Moral Sentiments* (1759) Smith made explicit his belief that “How selfish soever man may be supposed, there are evidently some principles of his nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it except the pleasure of seeing it” (p. 1).

While there are a potentially infinite range of internally consistent SVOs a decision maker might theoretically adopt, the vast majority of people in economic and social dilemma contexts have historically been classified into one of four idealized categories: competitive, individualistic, cooperative or altruistic (McClintock, 1972). Cooperative and altruistic preferences are generally referred to as “prosocial” motivations, while competitive and individualistic preferences are deemed “proself” (Kopelman et al., 2002, p. 118). These idealized SVO types, as well as many others, are often illustrated using the “SVO Ring” framework shown in Figure 1 (Murphy & Ackermann, 2014, p. 16).

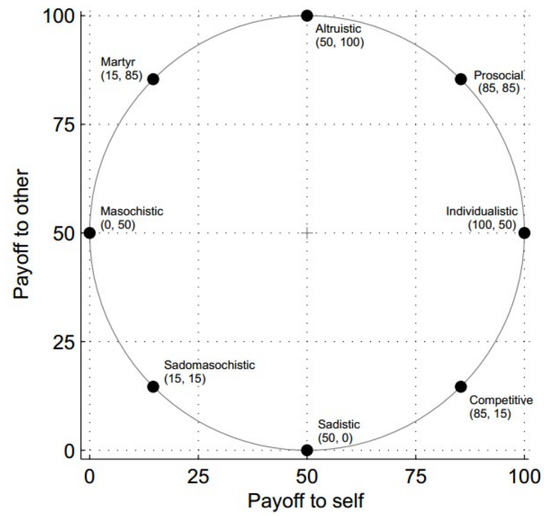

Figure 1: The SVO Ring

Originally presented by Liebrand (1984), the SVO Ring is a graphical representation of how individuals weigh their own material outcomes relative to the outcomes of others. Payoffs that decision makers assign to themselves are shown on the horizontal axis, while payoffs assigned to others are shown on the vertical axis. Points within the 360 degree circle represent all possible joint outcomes, while each cardinal direction along the outside of the circle represent different idealized SVO categories. The four most common SVOs of interest to economists are concentrated on the right hand side of the ring.

Decision makers who tend to prefer joint outcomes that maximize their own payoffs, and do not concern themselves with how this allocation effects the payoffs of others, are defined as “individualistic”. This SVO is equivalent to the theoretical ideal of self-interest commonly assumed by rational choice theory. In utilitarian terms, the only argument in a perfectly individualistic decision maker's utility function is assumed to be their own payoffs, while the payoffs of others do not factor into their internal calculus. This is shown by the farthest right, zero degree point along the SVO Ring (the 100/50 self-other point split).

In contrast, decision makers who tend to prefer distributions that maximize joint payoffs, and are thus sensitive to the gains or losses of others, are typically defined as “cooperative”. Perfectly cooperative decision makers maximize their utility by choosing distributions that maximize aggregate group payoffs, even if it entails accepting a lower private share. This is shown by the 45 degree point along the SVO Ring (the 85/85 self-other point split). Note that this SVO is sometimes also referred to simply as “prosocial”, as in the figure above. This is because within the cooperative category there is also a related prosocial preference regarding equity. The 45 degree point where joint payoffs are maximized also happens to be the same one where differences between payoffs are minimized. Therefore cooperation can refer to either joint maximization or inequality minimization. The difference between inequality averse and inequality tolerant forms of cooperation is an important distinction, as we will see later.

Although less common, “altruistic” and “competitive” social preferences are also observed in many circumstances. These two SVOs represent relatively extreme forms of prosocial and proself behavior respectively. Decision makers with perfectly altruistic preferences are assumed to prefer joint distributions that maximize the payoffs of others, while disregarding their own. This orientation is shown by the 90 degree point along the SVO Ring (the 50/100 self-other point split).

Conversely, competitive preferences concern the relative distribution of earnings. Decision makers who possess perfectly competitive preferences are assumed to derive utility by maximizing the distance between their payoff and those of others. This orientation is less concerned with the absolute value of any rents, and more interested in maintaining a relative advantage over others. This is shown by the -45 degree point along the SVO Ring (the 85/15 self-other point split).

Because utility is a purely theoretical construct which obviously cannot be directly measured, information on the social preferences an individual possesses must be inferred through other means. The most commonly accepted method in behavioral economics and psychology is the use of “decomposed games”, a revealed preference technique first developed by Messick & McClintock (1968). Although similar to the “dictator games” more common in pure economics (Kahneman et al., 1986; Forsythe et al., 1994), the decomposed game is actually a more general test of social preferences, and may contain dictator games nested within (Murphy et al., 2011, p. 779).

In a decomposed game, subjects are presented with a series of joint distribution items that require them to unilaterally assign different payoffs to themselves and another anonymous participant One subject is assigned the role of the “sender” while the other acts as a passive “receiver”. This distinguishes the task from “composed” games such as the Prisoner’s Dilemma, where all players have a strategic input on the outcome. Senders never learn who their choices ultimately impact, and receivers never learn the identity of the person making the decision. Because all choices are unilateral, independent and anonymous, and there are no opportunities for reciprocation or retaliation, strategic behavior theoretically does not enter into the decision-making process. This gives a clearer picture of the intrinsic distributional preferences subject's possess, free of confounding sub-games where decisions must be interpreted based on expectations of another player's response.

For example, consider a decision maker offered a simple one-shot, binary choice between two different distributions of currency, allocated between themselves, and some other anonymous individual. The joint distribution options for this choice are shown in Table 1 (Murphy & Ackermann, 2014, p. 34).

Table 1: Decomposed Game Example

Option A	Option B
You receive $150 Other person receives $50	You receive $85 Other person receives $85

If one assumes that the decision maker derives utility solely from their own payoff, and thus ignores the payoff of the other person, the utility maximizing decision will be the “individualistic” Option A. However, suppose the individual would derive more utility from ensuring that joint payoffs were maximized, even at the pecuniary cost of a lower payoff to themselves. In this case we would expect them to choose the “cooperative” Option B instead. Although both decisions are technically rational in the eyes of the decision maker, and neither is inconsistent with the principles of utility maximization, traditionally only Option A has been considered compatible with rational choice theory.

Obviously this example is heavily simplified, and is of little use other than to illustrate the general idea of the decomposed games technique. A wide variety of specific methods have been developed to estimate social preferences, each with its relative costs and benefits with respect to factors like item presentation, accuracy, decision consistency, the range of SVOs accounted for, statistical efficiency, etc. A comprehensive review of these methods is outside the scope of this paper,[1] but the two most commonly accepted approaches currently include the "Triple Dominance Scale" (Van Lange et al., 1997), and the "Ring Measure" (Brosig, 2002; Van Soest & Vyrastekova, 2006).The Triple Dominance Scale typically consists of nine multiple choice items that require decision makers to choose from joint distributions that represent various idealized SVO types. Whatever orientation "dominates" on average, is the preference they are assigned. The Ring Measure on the other hand employs a simple series of binary choice items to make a similar inference.

While these methods both have their advantages, they are limited by a number of common factors. Firstly, both measures ultimately reduce social preferences (an inherently continuous construct) to discrete categorical outputs based on idealized SVO types. This entails a significant sacrifice of statistical power and the loss of valuable information about preferences on the margins of each category. This problem can be compounded when preferences are further reduced simply to the proself and prosocial dichotomy (see Cohen, 1983), which is especially common with respect to the Triple Dominance Scale (Murphy and Ackermann, 2014, p. 33). It is preferable to have a measure that captures the relative intensity of proself and prosocial preferences as a ranked, and transitive continuum, rather than a discrete either-or category. Social preferences represent relative weights applied to different joint-outcomes, therefore continuous

1 See Murphy & Ackermann (2014) for a summary.

measurement is more consistent with the concept's theoretical origins (Griesinger & Livingston, 1973).

Secondly, neither measure adequately distinguish between decision makers that identify as cooperative due to an actual desire to maximize joint-payoffs, or because this joint distribution on the SVO Ring also happens to be one that tends to minimize inequality. While both forms of social preference lie along the prosocial range of the SVO Ring, and would be illustrated by the same 45 degree point, they are actually two very different cooperative motivations. This issue has largely been overlooked by prior studies. Failing to to account for the distinction in different forms of nominally cooperative preferences can result in the appearance of decision inconsistency (decision makers seemingly making choices at random) when the Ring Measure is applied (Ibid, p. 29). Sufficiently high levels of this apparent inconsistency can result in subjects being miscategorized or even erroneously excluded from a sample. This leads to potentially biased estimates of group composition, with certain SVOs (particularly on the prosocial end of the spectrum) being misrepresented in the sample. Van Soest & Vyrastekova (2006) for example, report unusually high proportions of proself orientations (82%) in their subject pool when employing a 24 item version of the Ring Measure, with decision consistency ranging anywhere from 72% to 92% (pp. 124-125).

Ideally, measures of social preference should be general enough to incorporate a wide range of prosocial and proself SVOs. They should also provide a ranked and transitive ordering of those preferences that is consistent with the continuous nature of SVO theory. Lastly decisions should be internally consistent, and properly distinguish between cooperative behavior motivated by the desire to maximize joint payoffs, or by the desire to minimize inequality. Given the diverse range of social preferences individuals can potentially adopt, and the need for a measure that can efficiently account for them, I now turn to my preferred estimation tool: the SVO Slider Method.

Design

The SVO Slider Method:

In order to empirically estimate social preferences I employ a relatively new measurement technique known as the SVO Slider Method (Murphy et al., 2011). This is a form of decomposed game that consists of six primary items designed to measure SVO over a high resolution spectrum, rather than categorically. This method produces a continuous variable in the form of an SVO index score that captures social preferences ranging from relatively proself orientations (competitive & individualistic) to relatively prosocial (cooperative & altruistic). In addition, it contains nine optional secondary items designed to disentangle cooperative social preferences motivated by pure joint maximization versus inequality aversion.

Besides being simple to administer and score, the SVO Slider Method offers several advantages over alternative decomposed game techniques like the Triple Dominance Scale and Ring Measure. Firstly, these methods rely heavily on discrete categorical data. By lumping decision makers into a limited set of SVO types, a great deal of nuanced information about preferences on the margins of these categories is lost. The SVO Slider Method instead generates a continuous measure representing the relative weight people place one their payoffs and the payoffs of others. This score provides a ranked and transitive measure of social preferences over a continuum ranging anywhere between highly proself (perfectly competitive) to highly prosocial (perfectly altruistic). While the index can also be evaluated categorically, this is largely for descriptive purposes or to allow straightforward comparisons with older methods. The real value of this variable is that it is an efficient tool for regression analysis, and can be used to easily control for social preferences when analyzing other data.

Secondly, by utilizing the full 15 item version of the test, the SVO Slider can also be used to distinguish between individuals who identify as cooperative due to a social preference for ordinary joint maximization, or inequality minimization. Alternative methods have either ignored this dimension, or misinterpreted inequality aversion among cooperative subjects as decision inconsistency. This reduces the potential for biased measures of group composition, or over-representation of certain SVOs (namely proself orientations) in the sample.

The SVO Slider Method is conducted by randomly matching decision makers with another anonymous participant (identified only as the "other") and presenting them with a sequential series of joint distribution items based on the traditional SVO Ring framework. However, unlike the Ring Measure or Triple Dominance Scale which present a fixed number of binary or multiple choice items respectively, the SVO Slider displays an intuitive continuum of joint payoffs using a quasi-continuous sliding scale. For example, consider a joint distribution item that ranges between two pre-defined endpoints, π_A and π_B inclusively.

The decision maker selects their preferred payoff, π_i anywhere between this range, and automatically assigns the other participant $\pi_j = (\pi_A + \pi_B) - \pi_i$. The user sees the values assigned to themselves and the recipient updated in real time, and after a check for comprehension, confirms their decision for each item. The ranges defining the six primary and nine secondary items are shown in Figure 2 (Murphy & Ackermann, 2014, p. 32).

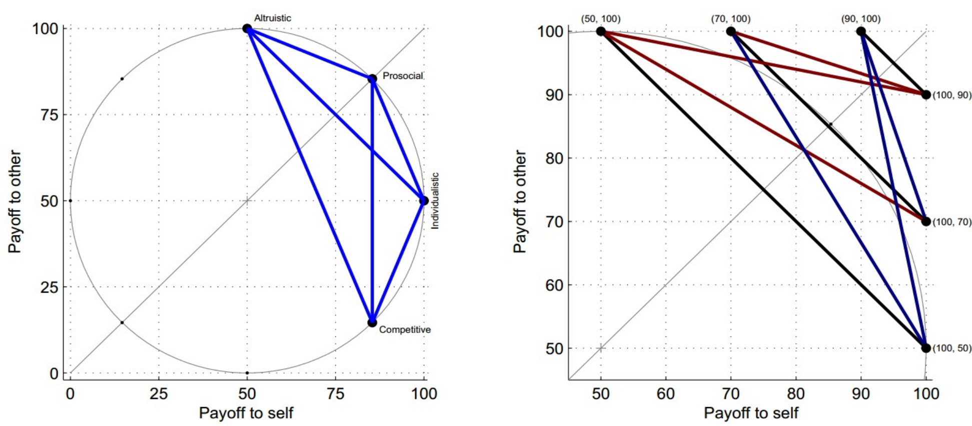

Figure 2: Primary & Secondary SVO Slider Items

For the six primary items, the endpoints that define each range correspond to cardinal points along the SVO ring connecting perfectly altruistic, cooperative, individualistic, and competitive joint distributions. Rather than forcing a decision maker to choose between options representing one set of endpoints or the other, this allows them to express consistent preferences in between SVO categories as well as on them. This provides us with a continuous and more accurate description of their ranked social preferences, with an added check for transitivity (for example if altruism if preferred to cooperation, and cooperation is preferred to individualism, then altruism must be preferred to individualism).

The nine secondary items are designed to distinguish between cooperative preferences motivated by pure joint maximization, and joint maximization conditioned on minimizing the level of of inequality between payoffs. The endpoints for these items are defined such that each one crosses a 45 degree line corresponding to perfectly equal joint distributions. Decisions made on or near the line indicate cooperation conditioned on limiting inequality (inequality aversion), while those on or near the endpoints indicate ordinary joint maximizing cooperation (inequality tolerance).

The SVO index score is calculated from the six primary items by first finding the ratio of average self and average other payoffs, shifted left to the middle of the SVO ring by subtracting 50 units. Taking the arctan of this variable produces the final index score in degree units shown by Equation 1.

$$SVO = \arctan\left(\frac{\bar{\pi}_j - 50}{\bar{\pi}_i - 50}\right) \tag{1}$$

This generates a continuous and transitive measure of social preferences ranging from relatively proself preferences to relatively prosocial. The higher (lower) the index score, the more prosocial (proself) the decision maker's SVO.

Based on the index scores associated with perfectly consistent preferences for each of the four idealized SVOs, categorical ranges for each orientation can also be defined. On the proself half of the spectrum, an SVO index less than -12.04 degrees indicates relatively competitive distributional preferences, while scores between -12.04 and 22.45 degrees indicates relatively individualistic. On the prosocial side, scores between 22.45 and 57.15 degrees indicates relatively cooperative distributional preferences, while a score above 57.15 degrees indicates relatively altruistic. The threshold values for each cardinal SVO category are more or less arbitrary, and need only be applied when discrete categorization is unavoidable (Murphy et al., 2011, p. 780).[2]

Based on the nine secondary items we can also distinguish between cooperative subjects who favor pure joint maximization (with no concern for equity) and those who pursue conditional joint maximization (contingent on avoiding increase in inequality). Dividing each cooperative subject's average normalized distance from distributions corresponding to perfect equality, $\bar{D}_{equality}$,

2 Because these four categories are not symmetrically distributed around the entire SVO Ring, index scores do not correspond exactly to the degrees shown on the the ring. Perfectly altruistic decisions for example, yield an SVO index of 61.39 degrees rather than 90 degrees. This results in the somewhat unintuitive threshold values defined above, however it does not adversely effect the measure's statistical power or validity (Murphy & Ackermann, 2014, p. 33).

by the sum of this value and the average distance from distributions corresponding to perfect joint maximization, $\bar{D}_{joint}$, produces a zero to one inequality aversion index given by Equation 2. (Crosetto et al., 2012, p. 5).

$$IA = \frac{\bar{D}_{equality}}{\left(\bar{D}_{equality} + \bar{D}_{joint}\right)} \tag{2}$$

An index value equal to zero indicates perfect inequality aversion. Conversely, a score equal to one represents a pure joint maximization preference, with no concern for changes in inequality (perfect inequality tolerance).

Common-Pool Resource Game:

The CPR dilemma component of the experiment is simulated in the tradition of Ostrom et al. (1994), and Van Soest & Vyrastekova (2006). This model was chosen to allow relatively straightforward comparisons to earlier experimental CPR studies. Consider a simple, static $t=1,\ldots,T$ round resource game. A rivalrous and non-excludable hypothetical resource is shared by $n\geq 1$ resource users. In each round every individual user $i=1,\ldots,n$ is endowed with a fixed quantity of effort, $e\geq 1$. The user can allocate their efforts between two revenue generating activities. The first is resource extraction, where $x_{i,t}$ equals the amount of effort individual *i* devotes to extraction in round *t*. Group extraction effort is the sum of all individual efforts, $X_t=\sum x_{i,t}$. The marginal costs of extraction, v, are assumed constant for simplicity. Group extraction revenues in round *t* are a function of total group extraction efforts, with a quadratic revenue function of the form, $R_t(X_t)=\alpha X_t-\beta X_t^2$. The individual user's share of group extraction revenue is proportional to their share of total extraction effort. Thus the individual extraction revenue of user *i* in round *t* is given by,

$r_{i,t}=(x_{i,t}/X_t)(\alpha X_t-\beta X_t^2)$.

The second activity in which a user can invest their efforts is assumed to be a non-resource related option that pays a fixed return, w , per unit of effort. Non-extraction effort is simply the total effort endowment minus the effort allocated to resource extraction. The user's revenue from this activity equals the fixed rate of return multiplied by the amount of non-extraction effort, $l_{i,t}=w(e-x_{i,t})$. The final profits of user *i* in an unregulated round *t* is summarized by Equation 3.

$$\pi_{i,t}(x_{i,t},X_t)=w(e-x_{i,t})+(x_{i,t}/X_t)(\alpha X_t-\beta X_t^2)-v\,x_{i,t} \tag{3}$$

The level of extraction effort is considered socially optimal when it maximizes the joint payoffs of the entire *n*-user group. The symmetrical, cooperative level of extraction effort is equal to $x_{i,t}^{*}=(\alpha-w-v)/2\beta n$. In a non-cooperative setting individuals seek to increase their own payoffs by exerting more extraction effort than is consistent with the social optimum. The symmetrical, Nash Equilibrium level of individual extraction effort is equal to $x_{i,t}^{\mathrm{N}}=(\alpha-w-v)/[\beta(n+1)]$. In both cases cases $(\alpha-w-v)>0$. Cooperative and competitive group extraction is simply $X_t^* = \sum x_{i,t}^*$, and $X_t^N = \sum x_{i,t}^N$, respectively. Note that a single user case where $n=1$, implies that $x_{i,t}^* = x_{i,t}^N$ (i.e. the Nash and optimal levels of extraction effort are identical). Given only one user, there are no competitive pressures to increase extraction effort beyond what is already efficient. However, when the number of users increases such that, $n>1$, so to does the Nash level of extraction effort until $x_{i,t}^* < x_{i,t}^N$. When the Nash level exceeds the social optimum a CPR dilemma occurs and Hardin's Tragedy of the Commons holds. This represents the unregulated, baseline stage of the CPR experiment that will form the within subjects control group.

To test the effect that peer-enforced regulation has on the CPR dilemma, the model can be extended to incorporate an endogenous enforcement mechanism. Suppose that in regulated treatment rounds each user is also endowed with a fixed amount of enforcement tokens, $s \geq 0$, after the initial extraction effort decisions have been made and revealed. These tokens can be held for a fixed return per unit kept (assumed to unity) or sent to other users to affect their final earnings. Each token sent changes the recipient's earnings by some impact ratio, p. Let the number of enforcement tokens sent to user *j* (where $j \neq i$) by user *i* in round *t* equal $\gamma_{ji,t} \leq s$ and the number of enforcement tokens user *i* receives from user *j* equal to $\lambda_{ij,t}$. The final profits of user *i* in an enforcement round *t* would then be given by Equation 4.

$$\hat{\pi_{i,t}} = \pi_{i,t} + s - \sum \gamma_{ji,t} + p \sum \lambda_{ij,t} \tag{4}$$

Profits in a regulated peer-enforcement round thus equals the user's initial unregulated profits, plus their unsent enforcement token endowment, minus the sum of tokens sent to other users, plus the sum of tokens received multiplied by the impact ratio. When $p < 0$, the tokens received represent a sanction that reduces the user's net payoff. All parameters and their associated values are summarized in Table 2.

Table 2: Experiment Parameters

Parameter	Description	Value
α	Extraction revenue function parameter	11.5
β	Extraction revenue function parameter	0.15
w	Non-extraction revenue per unit effort	1
c	Marginal extraction cost	1.5
n	Number of participants per group	5
T	Number of rounds per stage	10
e	Effort endowment	10
s	Sanction token endowment	6
p	Impact ratio	-2
$x_{i,t}^{*}$	Socially optimal user extraction	6
$x_{i,t}^{N}$	Nash equilibrium user extraction	10
X_{t}^{*}	Socially optimal group extraction	30
x_{t}^{N}	Nash equilibrium group extraction	50

Marginal cost and revenue function values were chosen to ensure extraction payoffs in the control stage would be non-negative, and also so total earnings would be sufficient to compensate subjects from each campus sampled for the opportunity cost of their time. In the event that sanctions received in an enforcement round exceeded extraction earnings such that $\hat{\pi}_{i,t}<0$, final profits were rounded up to zero to ensure subjects could not incur losses by participating in the experiment.

Experiment

Procedure:

Experimental sessions were conducted at the University of Alaska Fairbanks (UAF) and the University of Alaska Anchorage (UAA) in March and April during the Spring 2014 semester. Participants consisted primarily of undergraduate students of business and economics. Fairbanks area subjects were recruited directly from UAF undergraduate classes in economics and business, while those in Anchorage were recruited from an email database maintained by the UAA Experimental Economics Lab. All subjects were paid for their participation, receiving a lump sum show-up award, plus any game earnings.

Ten experimental sessions were conducted in total, involving between five and fifteen participants at a time (results were not sensitive to the number of simultaneous participants). Four sessions involving 25 subjects were conducted at the University of Alaska Fairbanks, followed by six sessions at the University of Alaska Anchorage involving an additional 60.[3] Session length averaged approximately 90 minutes. Sample statistics for each campus are provided in Table 3.

3 Due to technical problems, one session conducted at UAF was dismissed shortly after the start of the experiment. Five participants were given the opportunity to return and reattempt the experiment one week later. Results from this session were isolated and compared to other groups to test for contamination arising from the gap in completion. No statistically significant deviations in decisions or behavior were detected. Because its omission does not significantly alter any results or conclusions, the decision was made to retain this data in the analysis.

Table 3: Sample Statistics

Campus	UAF	UAA
Sample Size	N=25	N=60
Mean Age	21.3 (SD=3.6)	28.2 (SD=12.5)
Mean Years of Education	13.8 (SD=2.1)	14.5 (SD=3.0)
Percent Male	60.00%	59.30%
Show-Up Award	$10.00	$5.00
Mean Game Earnings	$15.92 (SD=3.10)	$16.98 (SD=1.18)

All experiments were administered digitally, and programed using the Zurich Toolbox for Readymade Economic Experiments (Z-Tree) (Fischbacher, 2007) (see Supplemental File 1 for code). After being checked in and completing the requisite informed consent paperwork (see Supplemental File 2), subjects were randomly assigned to private computer terminals and provided with instructions (see Supplemental File 3). Participants were informed that they would be playing a series of paid decision games with others attending that day, and that their game earnings would depend not only on their decisions, but also on the decisions of their peers. Experimental currency units were framed as “points”, with a point to dollar exchange rate of $0.02. Communication between participants was not permitted.

The experiment itself was divided into three stages. Instructions were delivered verbally at the start of each stage, with a break for questions in between.

In the first stage subjects played an “Anonymous Distribution Game” consisting of the full 15 item version of the SVO Slider test. This stage was programmed using customized code originally developed by Crosetto et al. (2012). Items were shuffled and displayed in the same order for each subject. After all choices were recorded, one randomly selected item was selected for payment. The subject received however many points they assigned to themselves, and their partner received the points assigned to them.

Stage two consisted of an unregulated CPR game played in groups of five. All decisions were made independently and simultaneously. Group members were identified only by a randomly shuffled Subject ID Label to prevent decisions from being connected between rounds. The game was framed as a decision about how many units of a hypothetical natural resource to extract from a stock shared among the group. In order to simplify the decision process subjects were only required to choose their level of extraction effort in each round, which was framed by the number of resource units extracted (a whole number between 1 and e=10, referred to as “my extraction”). They were told their earnings in each round would depend on how many units they decided to extract and how much the whole group (them included) extracted in total (referred to as “everyone's extraction”).

Participants were provided with a table summarizing all combinations of personal and group extraction decisions, and the associated point payoffs (see Supplemental File 4). In addition they were also asked to provide their best guess at what they expected group extraction would be in each round. After a thorough demonstration of how the table was interpreted, two unpaid practice rounds were played, followed by another opportunity for questions, and finally ten paid rounds. After everyone in the group made their individual extraction effort decisions and their best estimate of the group's total extraction effort, they were shown a screen summarizing the results of that round. Their unregulated extraction payoffs were automatically calculated and displayed for them. In addition, they were able to see information on the extraction levels and earnings of each member of their group, as well as in total.

The third stage consisted of a peer-regulated CPR game with an endogenous sanctioning mechanism. The procedure was similar to the previous stage, played for the same number of rounds, and with the same number of group members.[4] Subjects made their extraction decisions and estimates of group extraction just as before. However, in this stage after extraction earnings had been calculated and displayed, each subject was endowed with six enforcement (sanction) tokens. Subjects were told that these tokens could be used to add one point per token to their extraction earnings, or given to other group members to reduce the recipients extraction earnings by two points per token. After deciding how many tokens they wished to keep or send to other users, each subject's final regulated payoffs were calculated and displayed for them to see.

4 Group assignment was constant between stages, with the exception of one session where subjects were randomly re-shuffled following a power failure between stage two and three.

Hypotheses:

The Hardinian assumption that decision makers in CPR dilemmas can be universally described as rational and self-interested (i.e. perfectly individualistic) has traditionally been taken for granted in the social sciences. However this may or may not be a realistic description of social preferences for all decision makers. We routinely observe deviations from pure individualism in other forms of social dilemma where subjects may voluntarily contribute to public goods or abstain from defection in prisoner's dilemmas despite no seemingly self-interested incentive to do so. A more reasonable model of human behavior should incorporate the possibility of other forms of social preference, whether they be prosocial concerns for altruism, cooperation, or inequality aversion, or even other proself motivations like competition. Therefore, it would not be unreasonable to expect that participants in the subject pool may possess a diverse range of social preferences. This leads to Hypothesis One: the subject pool should display heterogeneity in the distribution of their social preferences, which may range anywhere from relatively proself orientations like competition and individualism, to relatively prosocial orientations like cooperation and altruism.

If we assume that proself subjects are concerned primarily with the maximization of their own relative or absolute payoffs, then we would expect these users to also display higher overall rates of extraction effort near Nash equilibrium levels in an unregulated CPR dilemma. Conversely if prosocial motivations of cooperation or altruism dominate, we would expect these users to display lower levels of extraction effort, closer to socially optimal levels. This brings us to Hypothesis Two: if intrinsic social preferences captured by a subject's SVO index carry over to strategic games, this score should be inversely related to unregulated extraction levels. In other words, subjects identifying as more prosocial (proself) should have lower (higher) rates of resource harvest, all else equal.

Lastly, because sanctioning is costly in the regulated treatment stage (each sanction token used costs the user one point) individualistic users should have no incentive to participate in a peer-enforced regulatory institution. Given the finite number of rounds, backwards induction suggests individualists should abstain from sanctioning and simply use their token endowment to increase their own earnings. Similarly, altruistic users should not engage in sanctioning because doing so is assured to reduce aggregate earnings.

Cooperative subjects may be willing to engage in enforcement, punishing those who extract more than the optimal level. However they must also consider the possibility that doing so may reduce joint earnings or increase inequality between individual payoffs. Sanction use among cooperative subjects is thus indeterminate. Competitive decision makers should be willing to use sanction tokens against all subjects in order to increase their payoffs relative to others in their group.

Because the predicted enforcement strategies tend to differ based on discrete SVO categories, Hypothesis Three is less clear-cut: individualistic and altruistic subjects should generally not participate in sanctioning during the regulated CPR stage, while cooperative and competitive users might. Competitive users should sanction those whose earnings exceed their own, while cooperative users may or may not sanction those whose extraction exceeds the social optimum.

Results

Social Value Orientation Experiment:

SVO scores for all 85 subjects were successfully estimated in stage one of the experiment using the SVO Slider Method. As discussed earlier, one of the main advantages of this technique is that it does not simply rely on a limited set of discrete SVO categories into which subjects must be lumped. Instead it produces a ranked and transitive measure of social preferences over a continuous spectrum of proself and prosocial orientations. In additional to being useful for regression analysis, this measure also allows us to plot a frequency histogram to see how SVOs are distributed among the sample. This distribution, with a bin size of five degrees is provided in Figure 3.

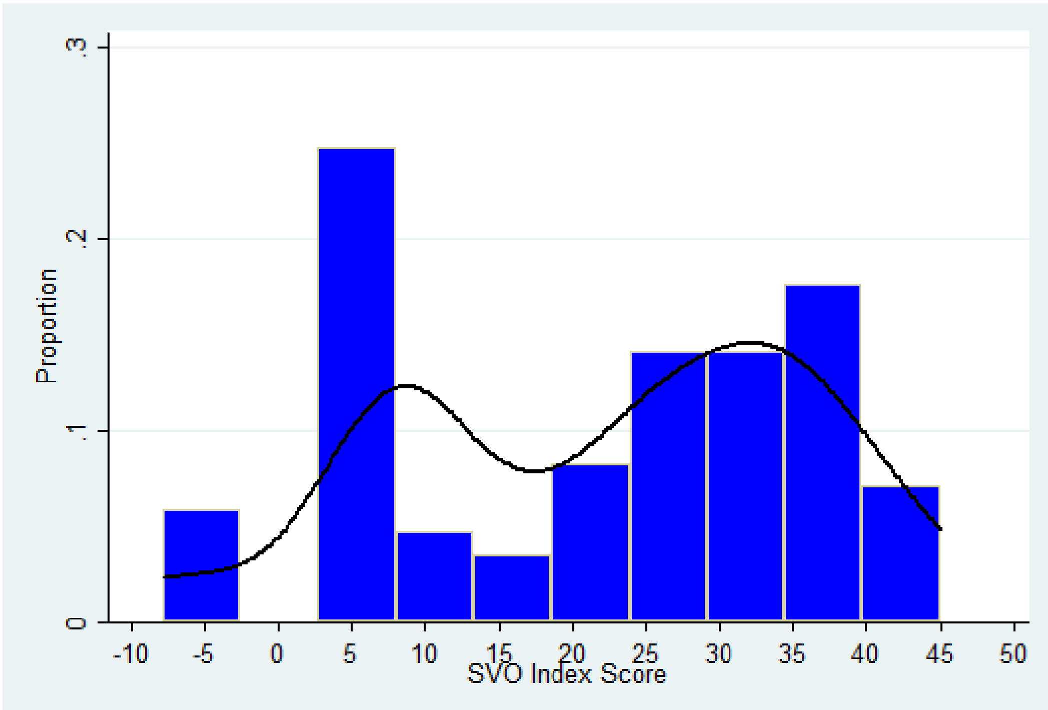

Figure 3: SVO Distribution

Moving from relatively proself preferences on the left hand side, to relatively prosocial on the right, there is clearly significant variation in how subjects value their own outcomes relative to others. Estimating a LOWESS smoothed kernel density function (Cleveland & Devlin, 1988) suggests a bimodal distribution (bandwidth = 0.5). The majority of the subject pool is clustered on the right, skewing the larger distribution towards the relatively prosocial (cooperative) end of the SVO spectrum. The smaller distribution skews left towards the proself (individualistic) end, clustering around the mode observation.

The function gradually tails off to the left, indicating relatively weak preferences on the more extreme end of the proself spectrum. These results largely mirror prior estimates of group composition using the SVO Slider Method on university-recruited subject pools (Murphy et al., 2011, p. 776).

Although SVO is best conceptualized as a continuous construct, traditional categorical analysis is also possible. Using the original threshold values established earlier, all 85 subjects can be classified by their predominant SVO type. While it should be noted again that the dividing lines between categories are more or less arbitrary (based largely on proximity to the nearest idealized preference), this information can still be useful for descriptive purposes, or to allow straightforward comparison to studies using alternative SVO measurement methods.

42.4% of the subject pool (N=36) can be categorized as consistently displaying individualistic behavior, i.e. behavior that largely conforms with self-interested profit maximization, and disregard for the payoffs of others. The mean SVO index within this range is equal to 7.95 degrees (SD=7.33). There is little variation in this category, with the majority of subjects concentrated around the mode SVO index of 7.82 degrees, which corresponds to perfect individualism. Of the 36 subjects who were classified as individualistic, 58.3% of those (N=21) displayed perfectly individualistic preferences, indicating that most participants in this range preferred joint distributions that maximized their own payoffs, regardless of how it impacted the payoffs of others.

The remaining 57.6% of the subject pool (N=49) can be categorized as consistently displaying cooperative behavior, i.e. behavior that largely conforms to joint profit maximization, and sensitivity to the payoffs of others. The mean SVO index within the prosocial range is equal to 32.61 degrees (SD=6.25). It is interesting to note that there is significantly more spread within this category relative to the individualistic range. This suggests that there may be wider variety of consistent prosocial orientations relative to the more proself side of the spectrum, an interesting nuance that would be overlooked by employing a simple discrete SVO measurement method.

Results from the secondary items allow us to extend the analysis of cooperative SVOs by distinguishing between subjects with pure joint maximizing preferences (but with no regard for the level of inequality between payoffs) and preferences that condition joint maximization on an equitable distribution of payoffs. The inequality aversion index scores for the 49 subjects that identified as cooperative are summarized in Figure 4, with a bin size of 0.1.

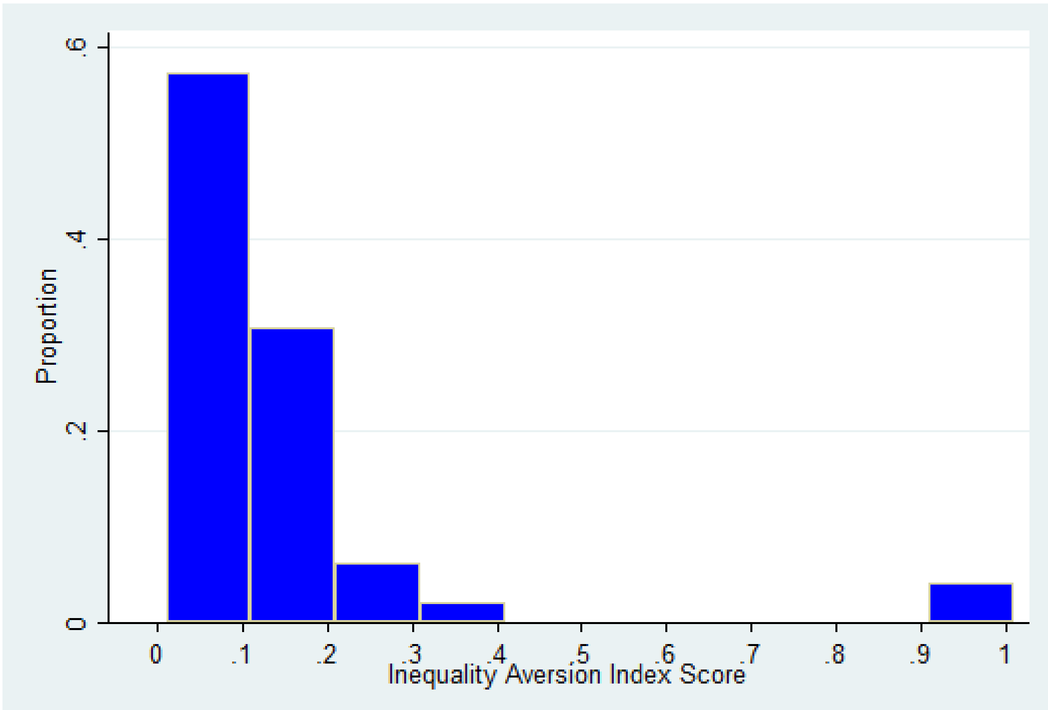

Figure 4: Inequality Aversion Index

Although there is heterogeneity in how prosocial subjects regard equity, the sample skews significantly towards the left-hand, inequality averse side of the spectrum. Dividing the index down the middle, and classifying subjects with an index score less than 0.5 as inequality averse, and those above 0.5 as inequality tolerant, suggests that the vast majority of cooperative subjects (96.0%) share a distaste for inequality and tend to conditionally maximize joint payoffs when doing so does not substantially reduce equality. Again, this is an interesting nuance in social preference, that would otherwise be ignored using older methods.

Finally, while there were several subjects with SVO scores near the threshold values for competitive and altruistic preferences, no one in the sample identified strongly enough with either orientation to be discreetly classified in these ranges. This finding is not particularly unusual given the non-randomly selected nature of the subject pool. The inherent selection bias associated with subject recruitment is a likely factor. We would not expect many people, especially college students, to volunteer for a paid social experiment only to arrive with a desire to largely give their earnings away to other participants (altruism). College campuses also tend to filter out overt anti-social behavior, therefore finding few subjects willing to sabotage others simply to increase their relative payoffs (competition) is not unusual either.

While the subject pool is not intended to be representative of the general population, it nonetheless provides some interesting insights into the composition and distribution of SVOs. Although social preferences are limited to just two of the available categories from the SVO Ring, preferences within these ranges are not homogenous. There is significant variation among cooperative subjects especially. It is also clear that SVOs are not uniform with respect to individualism. While perfect individualism is the most commonly occurring observation, relative to the entire sample it is in fact a minority preference, applying to only 24.7% of the 85 person subject pool. These nuances in social preferences would be largely overlooked by employing estimation techniques such as the Triple Dominance or Ring Measures.

The results of the SVO Slider experiment can be summarized with the following observations. Firstly, there is significant heterogeneity in the intrinsic motivations that drive resource allocation decisions. Only about one fourth of the total sample conforms to the perfectly individualistic social preferences commonly assumed by traditional rational choice theory. This confirms hypothesis one and suggests that blanket behavioral assumptions which rule out other-regarding preferences may not be universally applicable. Secondly, most decision makers that display nominally cooperative behavior, condition joint maximization on limiting increases in inequality. This inequality aversion is often overlooked by alternative tests of social preference which either ignore or misinterpret concerns for equity. This finding should be of interest to researchers interested in how perceptions of fairness influence decision making in social dilemma contexts.

It is important to remember that the SVO Slider Method, like all decomposed games, precludes the possibility of strategic behavior. Therefore, by themselves, these observations tell us very little about how social preferences might manifest under the strategic conditions of an actual natural resource dilemma. In order to determine if the intrinsic social preferences captured by the

SVO Slider Method carry over to CPR dilemmas we turn to stages two and three of the experiment.

Common-Pool Resource Experiment

After information on each subject's SVO was collected in stage one, subjects were randomly placed into five-person groups (N=17). Each group played ten incentive compatible rounds of a simple unregulated CPR game (stage two). This was followed by an additional ten rounds of a peer-enforced, regulated CPR game in which participants were also given the option to use a sanctioning mechanism to punish other users (stage three). Rounds one through ten represent the control stage of the CPR experiment with no regulation, while rounds eleven through twenty represent the within-subjects treatment under the enforcement institution. The socially optimal level of group extraction that would maximize joint payoffs was equal to thirty units per round, while the Nash equilibrium extraction level was equal to fifty units. Mean group extraction levels across all twenty rounds of the two stages are summarized in Figure 5.

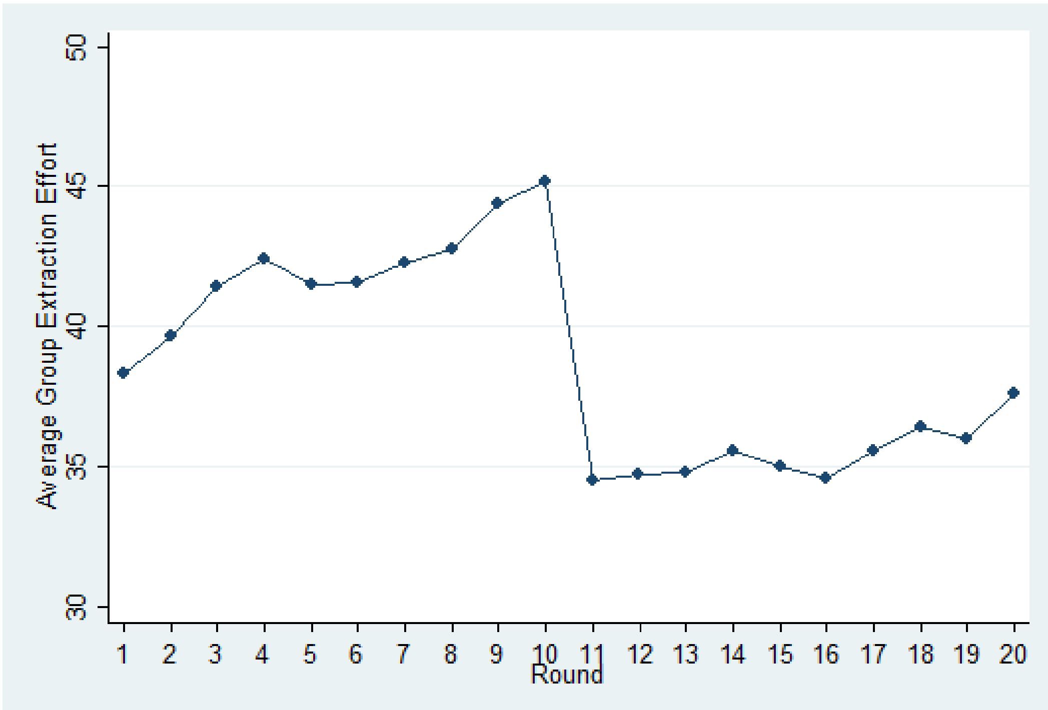

Figure 5: Average Group Extraction

Unregulated group extraction levels started well above the optimal level and trended upwards as the stage progressed. Average group extraction between rounds one through ten was equal to 42.0 units per round (SD=2.0). While extraction fell short of the predicted Nash extraction level, this was likely sensitive to the relatively short ten round length of the stage. Given enough rounds, unregulated extraction rates would likely continue to increase until the Nash level would be approximated.

The results of the unregulated CPR game confirmed an inverse relationship between subject SVO and average unregulated extraction efforts. This finding held whether using the continuous SVO index measure, or discrete SVO categories, and also when comparing subject-level or group-level decisions. The relationship between individual SVO indexes and average user extraction in stage two is shown in Figure 6.

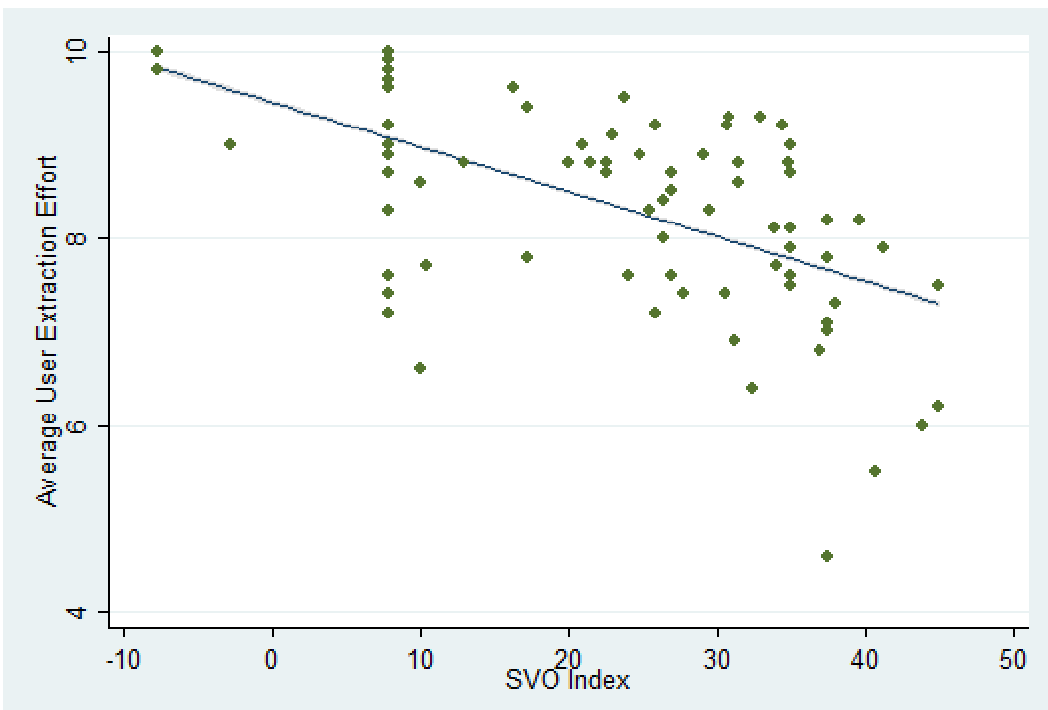

Figure 6: Average Unregulated Extraction

Based on a multiple regression holding other subject specific factors (gender, age, education and campus) constant, a 10 degree increase (decrease) in SVO score towards a more prosocial (proself) orientation was associated with a 0.5 unit decrease (increase) in average unregulated extraction efforts (p=0.000, R^2=46.2%). Evaluated discretely using the two SVO categories available, cooperative subjects extracted 1.1 fewer units than individualists on average (p=0.000). This suggests that all else equal, relatively more (less) prosocial (proself) preferences successfully predict lower (higher) rates of unregulated resource extraction.

The introduction of the sanctioning mechanism in round eleven led to a clear reduction in average group extraction efforts, with mean extraction falling to 35.5 units (SD=1.0), a statistically significant reduction of 6.5 units compared to stage two (p=0.000). This is consistent with prior research showing that peer-enforced sanctioning mechanisms can be used to reduce extraction levels and increase gross resource efficiency (Ostrom et al. 1992). While the trend towards increased extraction over time persisted, the rate of acceleration was lower than in the unregulated rounds. Average group sanction token usage over stage three is shown in Figure 7.

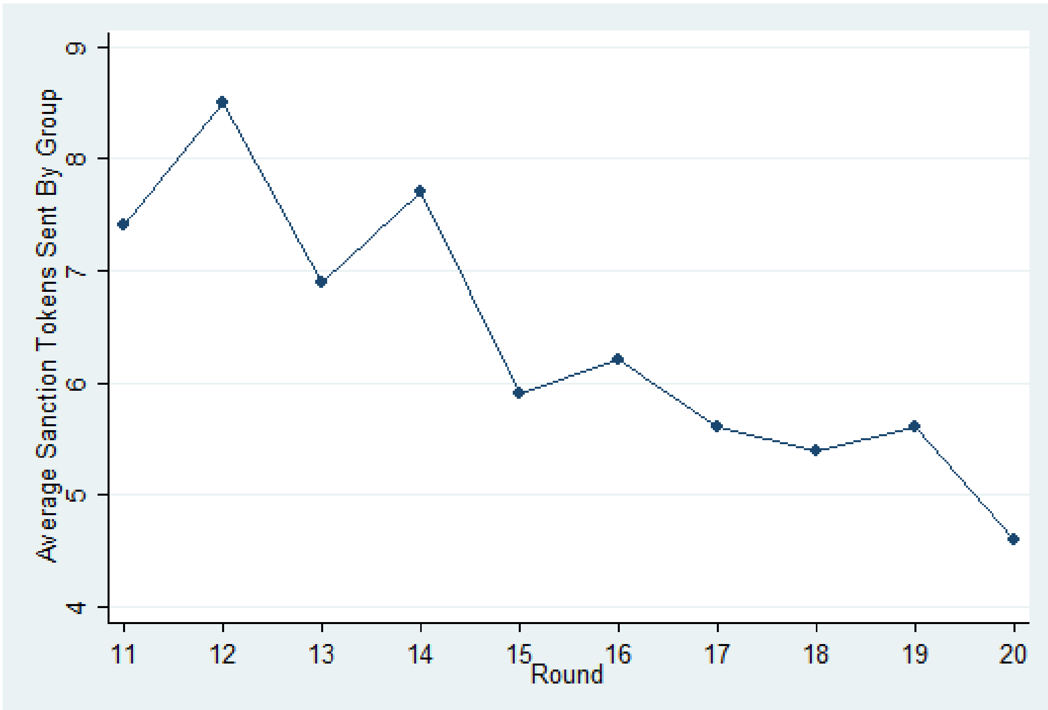

Figure 7: Average Sanction Usage

On average, groups used 6.4 tokens (SD=1.2) per round. Sanctioning occurred most frequently in the early rounds of the stage and declined steadily over time, which may partially explain why regulated extraction levels continued to trend upwards (albeit at a slower rate) even after introducing the possibility of punishment.

While SVO appears to be a good predictor of extraction effort in an unregulated CPR game (whether judged continuously using the SVO index, or categorically by SVO type), it was less reliable at predicting average sanctioning behavior in stage three. Analysis is complicated by the fact that the expected enforcement strategies of users differ based mainly on categorical SVOs, and the fact that only two of these orientations (individualism and cooperation) are present in our sample. Therefore only certain components of hypothesis three can be evaluated.

Contrary to game theoretical predictions that individualists should abstain from enforcement activities, sanction token usage was observed among both individualistic and cooperative subjects. Even more interesting is that on average, individualistic subjects tended to send more sanction tokens then their cooperative counterparts, although the difference between the two categories was not statistically significant (p=0.379). While there appeared to be an inverse relationship between the continuous SVO index measure and average sanction usage as well, it was also not significant (p=0.199).

This result seems unusual given that individualistic subjects are traditionally expected to have no incentive to contribute to group regulation, and should thus have lower (not similar) rates of sanction use. However this deviation from conventional rationality is largely consistent with prior studies such as Van Soest & Vyrastekova (2006) who also find that average enforcement levels between SVO types do not differ significantly (pp. 131-133). One possible explanation is that despite the finite number of rounds, individualists nonetheless believe that investing their sanction tokens towards affecting the extraction strategies of others will generate a higher return than simply holding them. This may be a learned behavior that develops over the course of the stage as evidenced by the fact that the relationship between SVO index and initial sanction use in the first round of stage three was positive and modestly significant ($p= 0.074$) as expected.

This suggests that relatively prosocial users may signal their willingness to sanction early in the initial rounds. Once the threat of punishment is established, the more individualistic subjects likely adjust their own extraction strategy accordingly and harvest at levels closer to optimal. Because this level of extraction is actually mutually beneficial, and results in higher private profits, individualists might internalize more cooperative tendencies by adopting a greater willingness to engage in the enforcement activity themselves. This would explain why differences in sanctioning strategies correlate to the initial sanctioning round, but not the stage on average. By incurring sanction costs early on, cooperative subjects appear to produce positive externalities, by inducing more prosocial behavior from subjects that previously adopted individualistic strategies absent the peer-regulation.

The best predictor of whether subjects received sanctions in a given round was, not unsurprisingly, their deviation from the average extraction level of the group, particularly when this deviation was positive (extraction was greater than the group average). This relationship is shown shown in Figure 8.

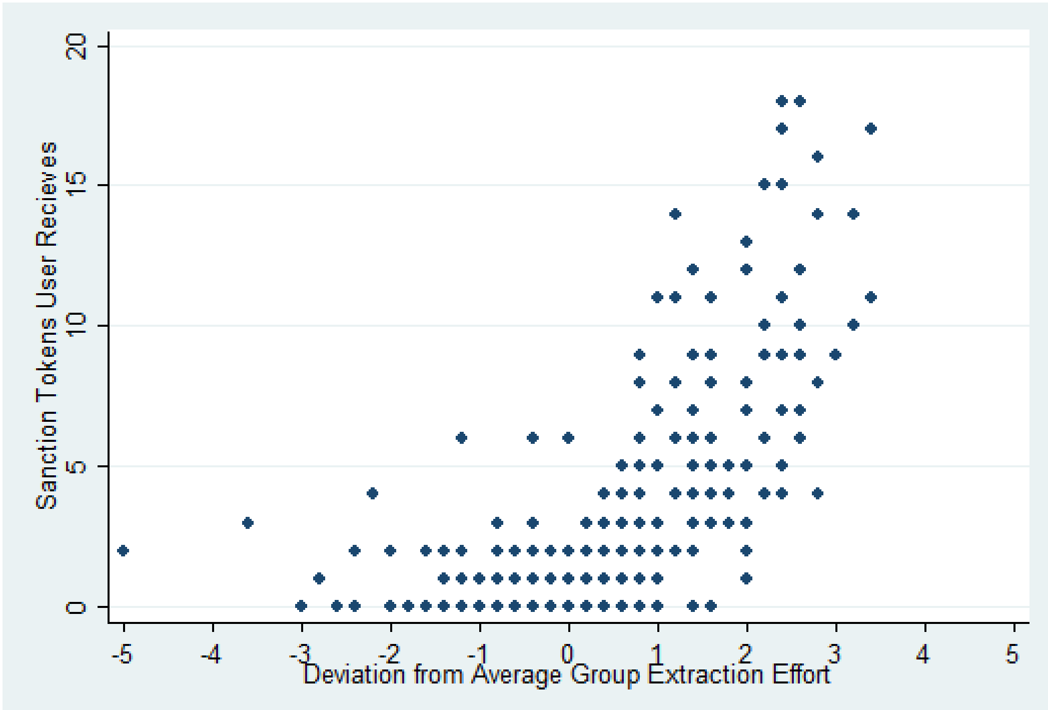

Figure 8: Sanctions Received

On average, subjects whose extraction effort exceed the group mean by 10% saw a 7.6% increase in sanctions received from other group members based on a semi-elastic simple regression (p=0.000, R^2=58.3%). Deviation from group norms in terms of average extraction was thus likely to be met with retaliation in the form of higher sanctions received.

The results of the CPR experiment can be summarized with the following observations. Firstly, while extraction levels in the unregulated stage do not reach Nash levels, they are well above the social optimum, and tend to increase over time. This suggests that the Tragedy of the Commons may be a reasonable starting point for modeling long-run CPR dilemmas in the absence of any institutional constraints. However, institutions are not the only determinant of extraction decisions in the dilemma. Social preferences play an important role as well, with harvest levels of prosocial users falling significantly below their more proself counterparts. This implies that unregulated extraction in a CPR dilemma is sensitive not just to the rules of the game, but also the social preferences of resource users. Given a homogenous group composed entirely of individualistic (cooperative) users we would expect to see higher (lower) rates of resource extraction, resulting in outcomes that better approximate the Nash (socially optimal) equilibrium. It is possible that a homogenous user group composed entirely of highly cooperative subjects would be able to maintain better than rational harvest levels over repeated iterations, avoiding (or at the very least postponing) the descent into a Tragedy of the Commons.

While SVO is a good predictor of extraction decisions, it is less useful as a predictor of participation under the peer-enforced regulatory institution, at least with respect to the round average. Sanction usage is observed among both individualistic and cooperative SVO types in statistically equal measure on average, which is unusual given game theoretical predictions that individualists should largely abstain from costly enforcement activities. Enforcement behavior may better explained by focusing on the initial rounds of the game, where sanctioning is most concentrated. As soon as enforcement tokens are introduced, prosocial users do display significantly higher levels of sanction use, as theory predicts. Cooperative users appear to signal their willingness to punish users who deviate from the group's average extraction level early on. Once this threat is established, individualistic users respond by reducing their extraction levels, and becoming more willing to use sanction tokens themselves. This results in the behavioral differences between cooperative and individualistic users subsiding over time, as evidenced by statistically similar sanction use and harvest levels once averaged over the duration of the stage.

Conclusion

The Tragedy of the Commons is a convenient metaphor, and probably a reasonable starting point for the analysis of pure CPR dilemmas. However its strict assumptions regarding the rational, self-interested social preferences of resource users are not entirely accurate. While many decision makers can be described as individualistic, economists should exercise caution in applying this SVO label to all resource users. Using simple experimental methods, this study finds that people also adopt a wide variety of other, more nuanced SVOs, including (but not limited to) strong preferences for other-regarding cooperation and inequality aversion. Even within nominally identical SVO categories there is still significant variation in how strongly people identify with a given behavioral type. While the subject pool may not be representative of the general population, it is interesting to note that only a minority of the sample conformed to the perfectly individualistic orientation predicted by standard rational choice theory.

By employing a continuous measure of social preferences via the SVO Slider Method, my findings confirm that the intrinsic values people possess can reliably predict certain behaviors under strategic CPR games. I find that relatively prosocial (cooperative) preferences are associated with significantly lower rates of resource harvest relative to more proself (individualistic) orientations, holding other subject specific factors constant. Similarly, groups with higher proportions of prosocial users extract less on average than groups composed principally of proself users. This suggests that the efficient long-run use of natural resources depends not just on institutional regimes or lack thereof, but also on the social preferences and group composition of the users themselves. We may observe open-access CPRs appropriated by communities with higher proportions of prosocially oriented users to be used more efficiently than those where proself tendencies dominate. None of this would be terribly surprising to anyone but economists, who have historically expected that individualism will always crowd out other-regarding preferences in the absence of formal or informal institutional regulations (Bolle, 1980).

Social preferences can also be a useful predictor of participation in a peer-enforced regulated CPR dilemma, although the relationship is less clear. While average sanction use is statistically identical between prosocial and proself subjects, initial sanction use is significantly and positively related to prosociality like one would expect. Cooperative subjects appear to signal their willingness to sanction early in the game, and individualists lower their harvest accordingly. Once it becomes apparent that closer to optimal rates of extraction can result in higher private payoffs, individualists may become more willing to participate in enforcement themselves, and sanction others whose extraction tends to stray from the group mean. This suggests that sanctioning by cooperative users creates positive externalities, by promoting more prosocial behavior among otherwise individualistic users. This institutional heterogeneity certainly warrants further study, and could be better captured by future experiments designed to account for it explicitly.

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